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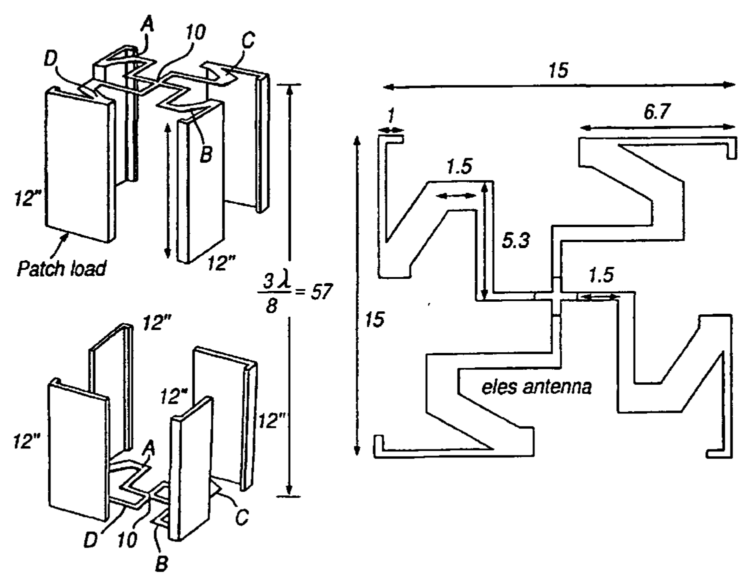
(54) Title: AN ANTENNA



(57) Abstract: An antenna element comprising a set of generally coplanar elongate conductive members coupled in series, the set including a feed member (2, 2') for receiving an antenna feed (10), a first member (4, 4') coupled to the feed member (2, 2'). The first member (4, 4') may extend generally at right angles to the feed member (2, 2') and the element may additionally include a second member (6, 6') coupled to the distal end of the first member, an intermediate member (18) coupled between the first and second members (4', 6') and/or a third member (20) coupled to the distal end of the second member (6'). The two additional members extend generally parallel to the feed member (2').

WO 01/80358 A1

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AN ANTENNA

This invention relates to an antenna which is intended particularly though not exclusively, for compact operation with a mobile handset in a mobile terrestrial or satellite system or as a small antenna for communicating with a satellite.

In accordance with the invention there is provided an antenna element comprising a set of generally coplanar elongate conductive members coupled in series, the set including a feed member for receiving an antenna feed, a first member coupled to the feed member and extending generally at right angles to the feed member and a second member coupled to the distal end of the first member.

Antenna elements and antennas embodying the invention will now be described by the way of example with reference to the drawings in which:

Figure 1 is a schematic plan view of an element of an antenna;

Figure 2 is a schematic plan view of a plurality of the elements of Figure 1 arranged to form an antenna;

Figure 3A is a schematic perspective view of a modified form of the antenna of Figure 2;

Figure 3B is a schematic perspective view of a modified form of the antenna of Figure 2;

Figure 4 is a plot of standing wave ratio against frequency for antenna of figure 3A and 3B;

Figure 5A is a polar plot of antenna normalized gain for the antenna of Figure 3A and 3B when coupled to produce left-hand circular polarisation;

Figure 5B is a polar plot of antenna normalized gain for the antenna of Figure 3A and 3B when coupled to produce right-hand circular polarisation;

Figure 6 is a polar plot of the antenna normalized gain through the vertical axis of the antenna of Figure 3A and 3B when used in conjunction with a ground plane;

Figure 7A is a schematic view of a modified form of the antenna of Figure 2;

Figure 7B is a schematic plan view of a plurality of the elements of Figure 7A arranged to form an antenna;

Figure 8A is a schematic perspective view of an antenna array formed from two antennas of the type shown in Figure 7B and having a metallic patch load coupled to each element of each antenna ;

Figure 8B is a schematic perspective view of the lower antenna array of Figure 8A and having an alternative metallic patch load coupled to each element of the antenna;

Figure 9A is a polar plot of antenna normalized gain in the vertical plane for the antenna array of Figure 8A coupled to produce co-polar left-hand circular polarisation;

Figure 9B is a polar plot of antenna normalized gain in the vertical plane for the antenna array of Figure 8A coupled to produce cross-polar right-hand circular polarisation;

Figure 9C is a polar plot of antenna normalized gain in the horizontal plane for the antenna array of Figure 8A coupled to produce co-polar right-hand circular polarisation;

Figure 10 is a feed network for the antenna array of Figure 8A;

Figure 11A is a schematic side elevation of an alternative form of the antenna of Figure 7B;

Figure 11B is a schematic perspective view of the antenna of Figure 11A;

Figure 11C is a schematic plan view of the antenna of Figure 11A;

Figure 12A is a polar plot of the vertical normalized gain radiation pattern of the antenna of Figures 11A, 11B and 11C coupled to produce left-hand circular polarisation; and

Figure 12B is a polar plot of the vertical normalized gain radiation pattern of the antenna of Figures 11A, 11B and 11C coupled to produce cross-polar right-hand circular polarisation.

Figure 1 shows a single element which may be used to build an antenna as described below.

The element has a feed member 2, a first member 4 and a second member 6. An intermediate feed member 8 extends in the same direction as the feed member 2 and is wider than the feed member 2. The first member preferably extends at right-angles to the feed member 2. Also, the second member 6 preferably makes an acute angle θ with the first member 4.

The antenna of Figure 2 is formed form four conducting elements A,B,C and D of the type shown in Figure 1. The elements A, B, C and D are arranged in the same plane and equiangularly around a central feed 10. The elements B, C and D are fed with a consecutive 90 degree phase lag (relative to the feed for element A) in a clockwise order

to produce left-hand circular polarisation out of the plane of the drawing. Alternatively, the antenna may be fed with a 90 degree phase lag in the anti-clockwise direction in which case the polarisation is right-hand circular.

The antenna may, for example, be constructed from wire or (as will be described below) may be printed on a dielectric substrate.

The resonant frequency and impedance bandwidth of the antenna may be varied by changing the total length of each element of the antenna and/or by adding a metallic load 12 at the distal end of each element as shown in Figure 3A.

The metallic load can be altered, for example, to increase the impedance bandwidth such as shown in Figure 3B. In this case, the metallic loads 12' comprise a small patch 14 in the plane of the antenna and semi-circles 16 extending normal to the plane of the antenna. The path followed by the semicircles 16 is, in plan, similar to that of the metallic loads 12 of Figure 3A.

As shown in Figure 4, an antenna of the type shown in Figure 3A (with dimensions R=30mm, S=12mm, T=12.8mm, U=30mm, V=2mm, W=5mm, X=10mm, Y=9.5mm, and Z=1mm) is resonant at a frequency of 2.1GHz and has a bandwidth for a standing wave ratio better than 2:1, of 10%.

For an antenna of the type shown in Figure 3B (with dimensions R'=30mm, S'=10mm, T'=0.3mm, U'=30mm, V'=2mm, W'=5mm, X'=7mm, and Y'=4mm) Figure 4 shows that it is resonant at a frequency of 2.14GHz and has a bandwidth for a standing wave ratio better than 2:1 of 11%.

Figures 5A and 5B show the normalised gain of the antennas of Figures 3A and 3B.

For mobile usage, it is usually desirable to reduce or suppress radiation directed downwardly towards the ground. The addition of a ground plane parallel to the plane of the antenna of Figure 3A or 3B and located below the plane of the elements at a distance equivalent to a quarter of the resonant wavelength of the antenna, produces the type of radiation pattern shown in Figure 6. As will be seen, the majority of the radiated power is radiated upwardly.

The element of Figure 7A is based on that of Figure 1. This modified element has first and second members 4' and 6', a feed member 2' and an intermediate feed member 8'. In addition, the modified element has an intermediate member 18 coupled between the first and second members 4' and 6' and a third member 20 coupled to the distal end of the second member 6'. The two additional members extend generally parallel to the feed member 2'.

Preferably, the feed member 2' and the intermediate feed member 8' are of the same width. Also, the third member 20 may be wider than the intermediate member 18. The angle α between the intermediate portion 18 and the second portion 6' may be any angle but is preferably acute as shown.

The modified elements may be arranged in the same way as the elements shown in Figure 2, to produce an antenna array of the type shown in Figure 7B

An alternative approach to the use of the ground plane described above, is to use two of the antennas of Figure 2 or figure 7B located above one another as shown in Figure 8A.

The central feed 10 of each antenna is aligned on a line passing generally orthogonally through a plane parallel to those of the antenna elements and have patch loads 12" which extend about 18mm (for the plots shown in Figures 9A, 9B and 9C) towards each array.

The antennas are preferably separated by about 3/8ths of the resonant wavelength (57mm in the antenna used as an example) of the array and fed with a 45 degree phase difference. The array of Figure 8A produces the radiation patterns shown in Figure 9A, 9B and 9C. Figure 9A shows the pattern when the elements C and D are fed to produce left-hand circular polarisation with the cross-polar radiation pattern in figure 9B.

The metallic load can be of any form to control the input impedance and its bandwidth e.g. a semi-circle coupled with a normal patch load as shown in Figure 8B.

With reference to Figure 10, one way of obtaining the 45° phase difference is to couple the (upper array, element-2, phase-135°) by a transmission line to the (lower array, element-1, phase-0°) and for all of the other elements to be connected as shown in Figure 10.

The size of the antenna may also be reduced by printing the configuration shown in Figure 2 or 7B on opposing faces of a cuboid of dielectric material. This is shown in Figures 11A, 11B and 11C.

The antennas shown in figure 11A, 11B and 11C typically have the same configuration as the antennas in figure 1. For example, feed member 2 and intermediate feed member 8 are of equal size and longer than in figure 1 . The second member 6 in Figure 1 is optional depending on the desired resonant frequency.

Using a material having a relative permittivity of 36, the dimensions of the antenna are 10 x 10 x 20 mm to produce an antenna having the radiation patterns shown in Figures 12A and 12B at a resonant frequency of 1.1GHz.This antenna array may also be fed by the feed network as shown in Figure 10.

CLAIMS

1. An antenna element comprising a set of generally coplanar elongate conductive members coupled in series, the set including a feed member for receiving an antenna feed, and a first member coupled to the feed member.

2. An antenna element according to claim 1, including a second member coupled to the distal end of the first member.

3. An antenna element according to claim 1 or claim 2, wherein the first member extends generally at right angles to the feed member.

4. An element according to claim 2 or claim 3, wherein the second member extends in a direction which is not parallel to the direction of extension of the feed member.

5. An element according to any of claims 2 to 4, wherein the set further includes an intermediate member coupled between the first and second members and extending in a direction parallel to the feed member.

6. An element according to claim 5, wherein the intermediate member is wider than the feed member.

7. An element according to any of claims 2 to 6, wherein the set further includes a third member coupled to the distal end of the second member and extending in a direction parallel to the feed member.

8. An element according to claim 7 when dependent on claim 5 or claim 6, wherein the third member is wider than the intermediate member.

9. An element according to any preceding claim, wherein the set further includes an intermediate feed member which extends generally in the same direction as the feed member and which is coupled between the feed member and the first member.

10. An element according to claim 9, wherein the intermediate feed member is wider than the feed member.

11. An element according to any preceding claim, including a metallic load element coupled to the distal end of the element and operable to alter the impedance and/or bandwidth of the element.

12. An antenna array comprising a plurality of the antenna elements of any preceding claim, the elements being arranged in the same plane, generally equiangularly around a central feed and each feed member being coupled to the central feed.

13. An antenna element constructed and arranged as described herein with reference to the drawings.

14. An antenna constructed and arranged as described herein with reference to the drawings.

1/7

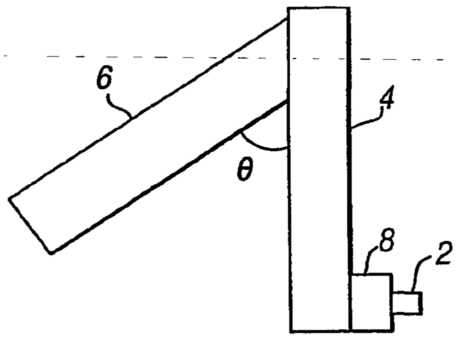


Fig.1

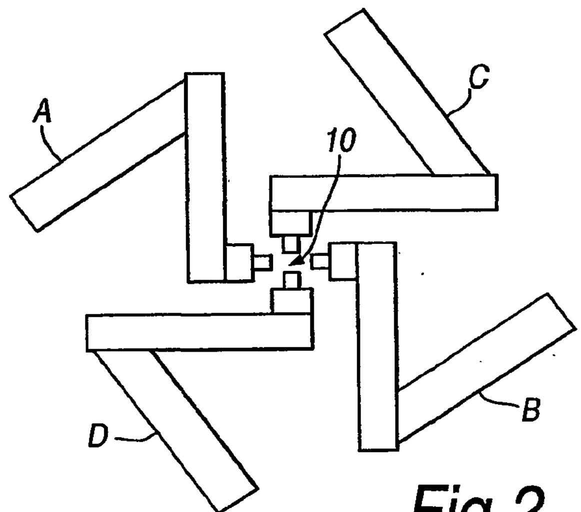


Fig.2

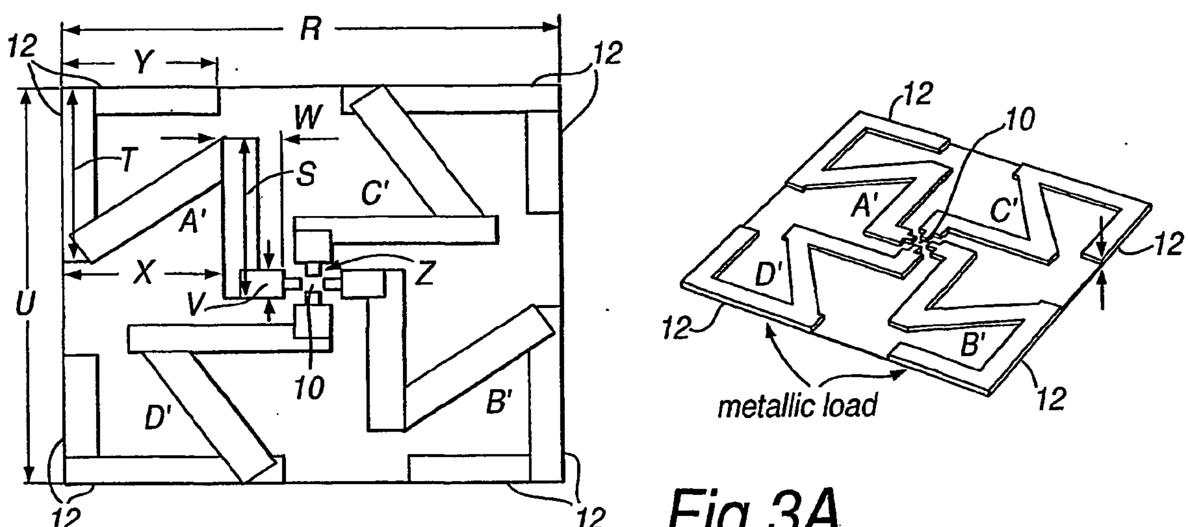
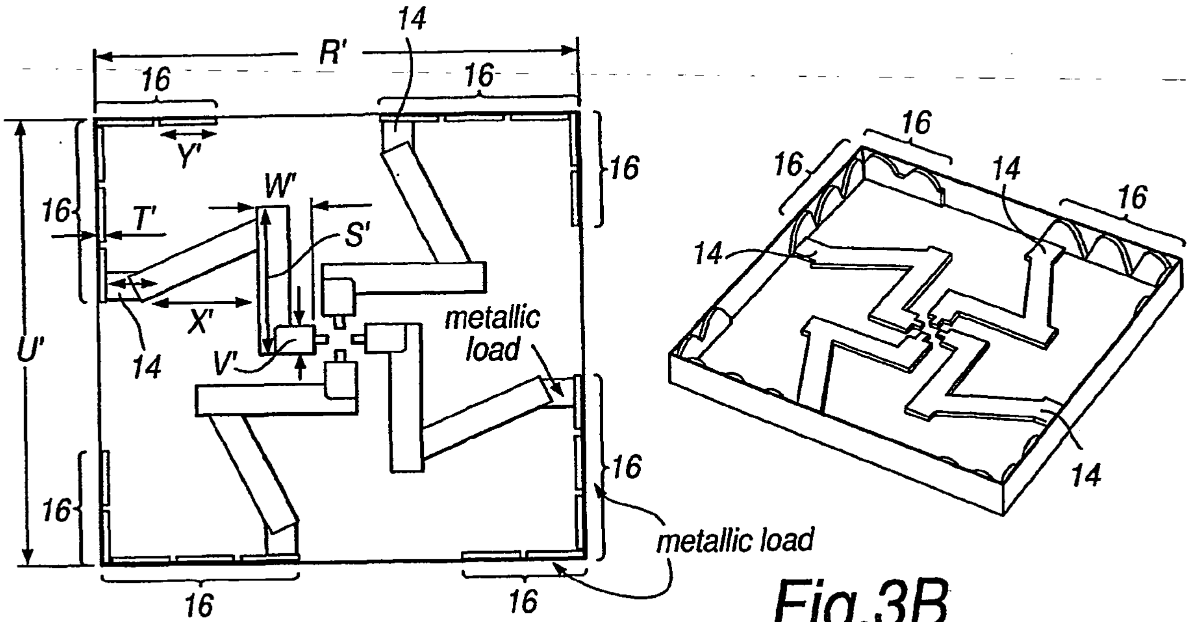
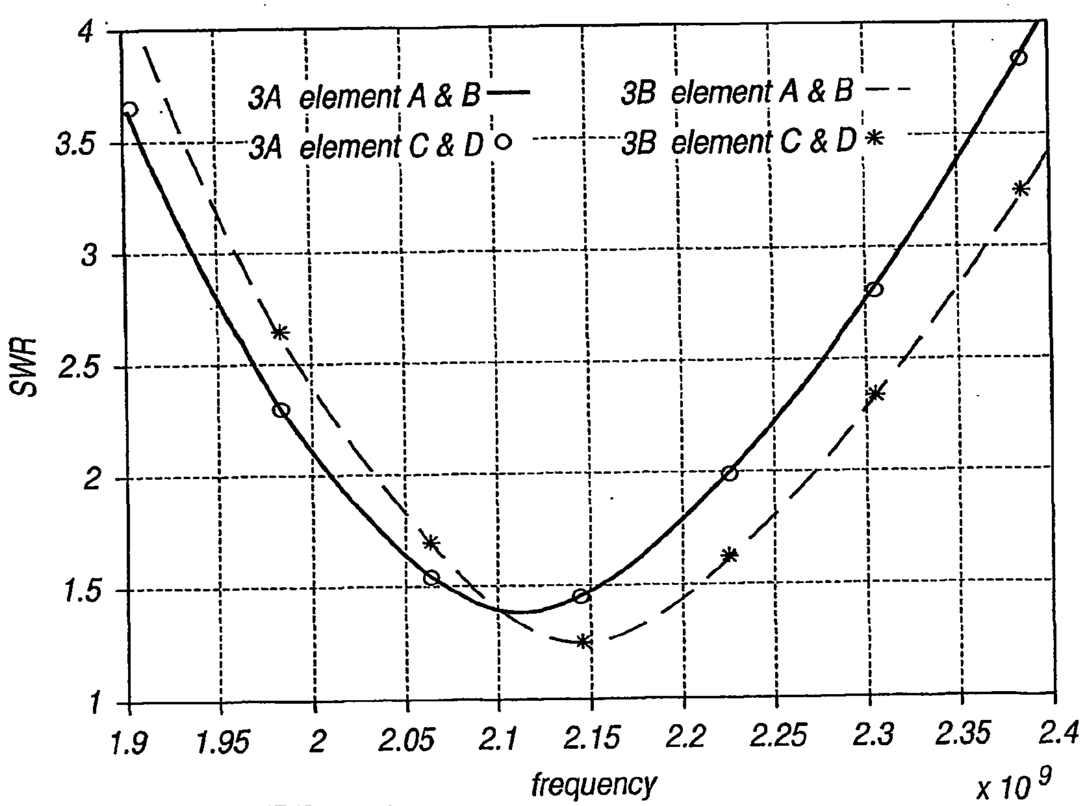


Fig.3A



R'
16
14
16
Y'
16
W'
16
T'
S'
X'
14
metallic
load
U'
V'
16
16
metallic load
16
16
16
16
14
16
14
14

Fig.3B



3A element A & B
3A element C & D
3B element A & B
3B element C & D
SWR
frequency
x 10^9
4
3.5
3
2.5
2
1.5
1
1.9
1.95
2
2.05
2.1
2.15
2.2
2.25
2.3
2.35
2.4

Fig.4

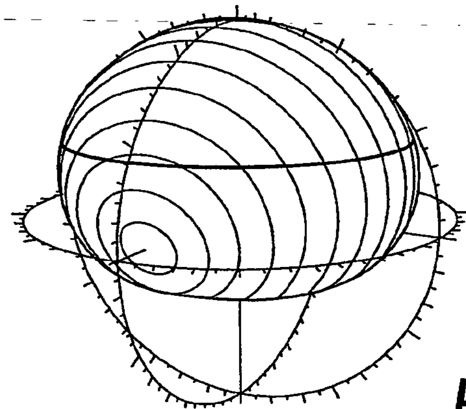


Fig.5A

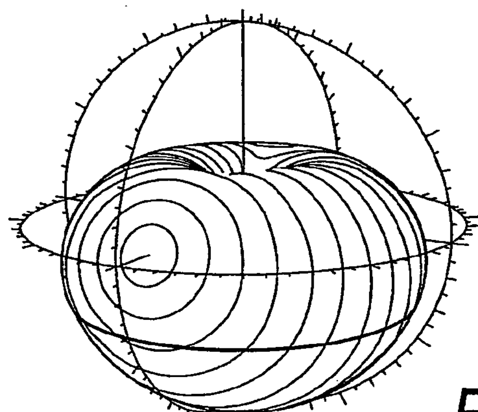


Fig.5B

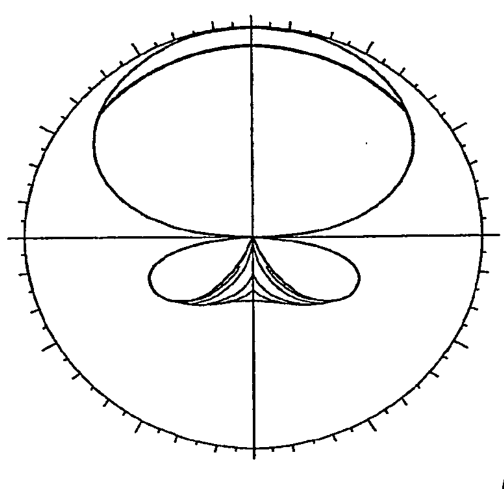


Fig.6

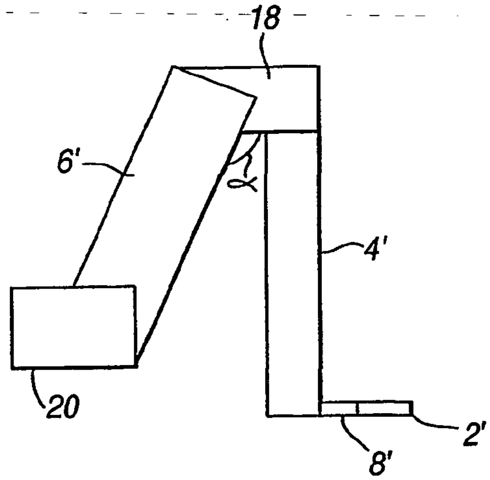


Fig.7A

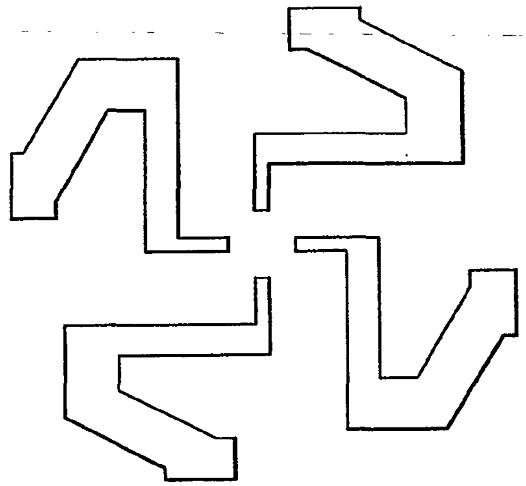


Fig.7B

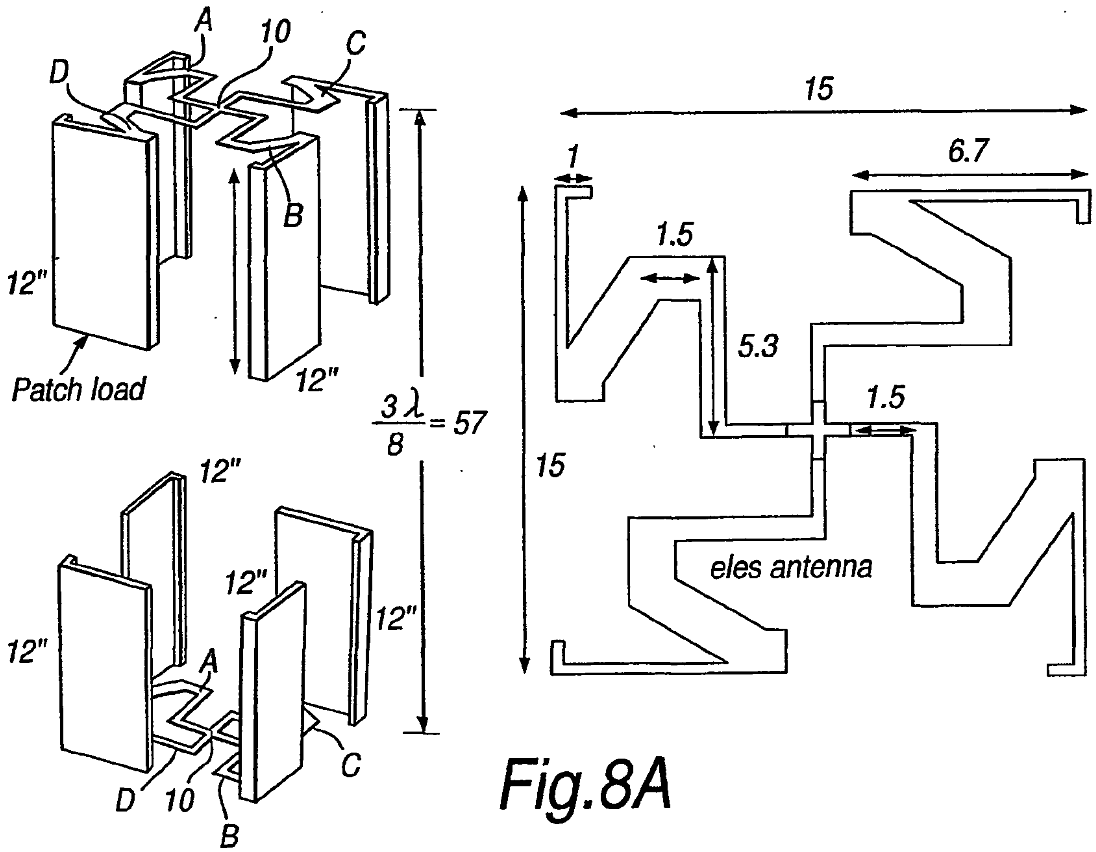


Fig.8A

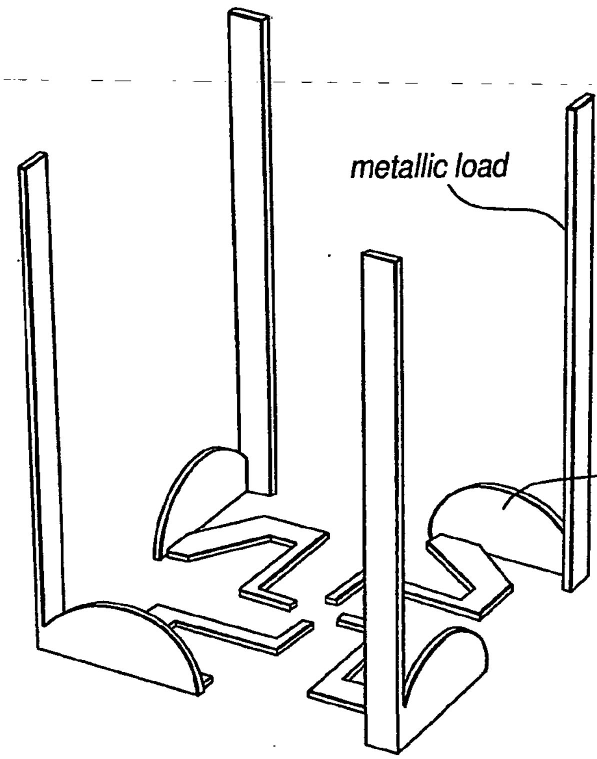

metallic load
metallic load

Fig.8B

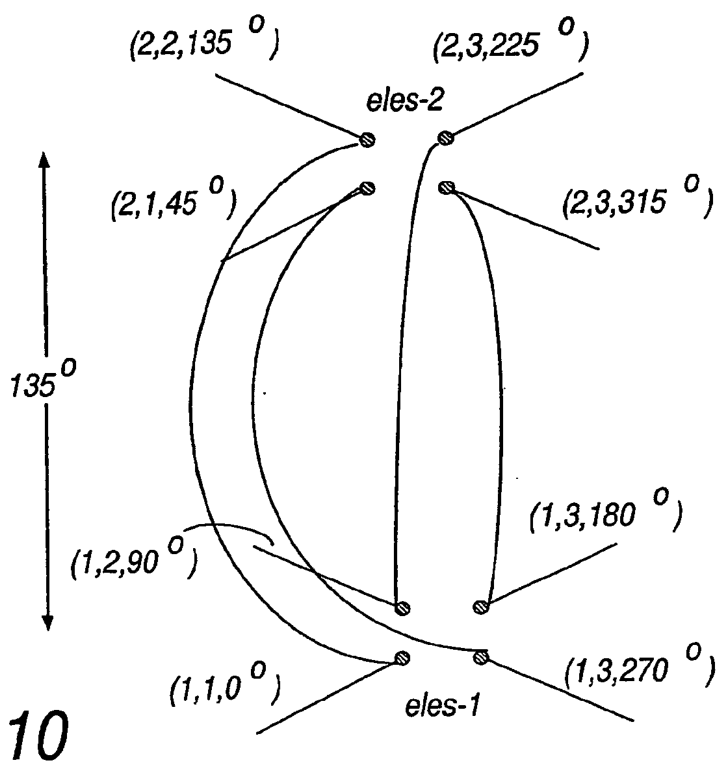

(2,2,135 °)
(2,3,225 °)
eles-2
(2,1,45 °)
(2,3,315 °)
135°
(1,3,180 °)
(1,2,90 °)
(1,1,0 °)
(1,3,270 °)
eles-1

Fig.10

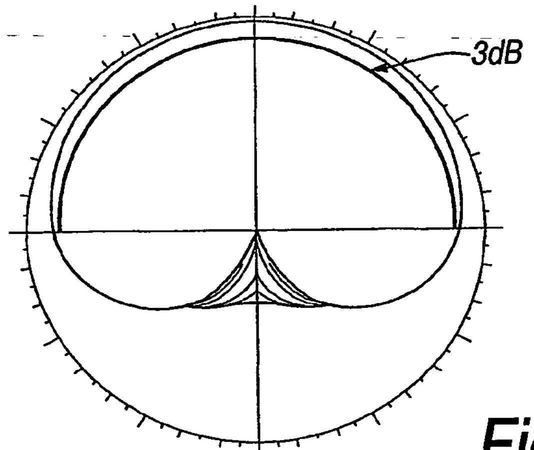


Fig.9A

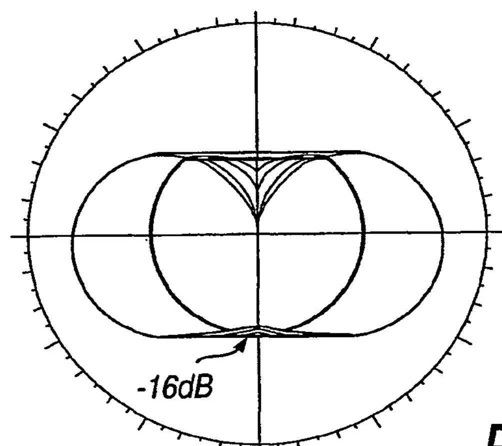


Fig.9B

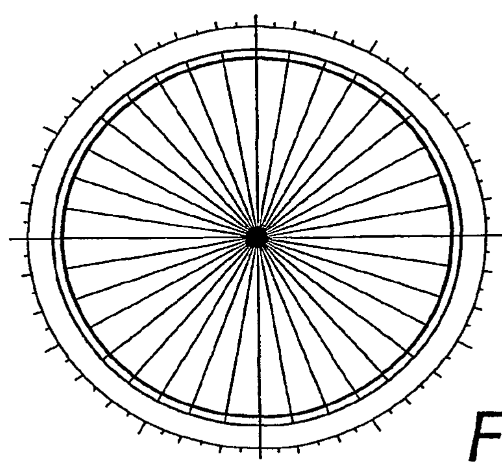


Fig.9C

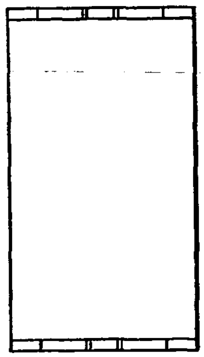


Fig11A

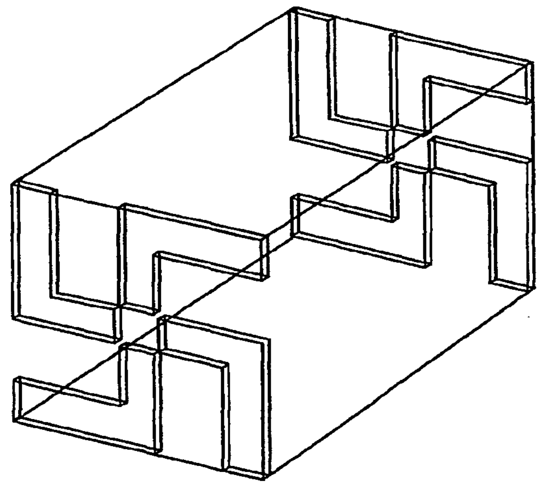


Fig11B

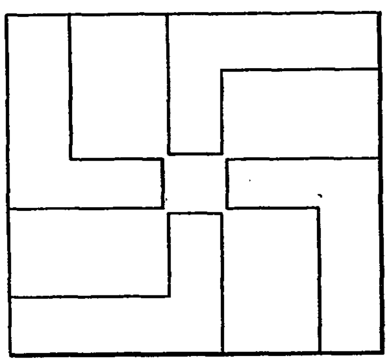


Fig11C

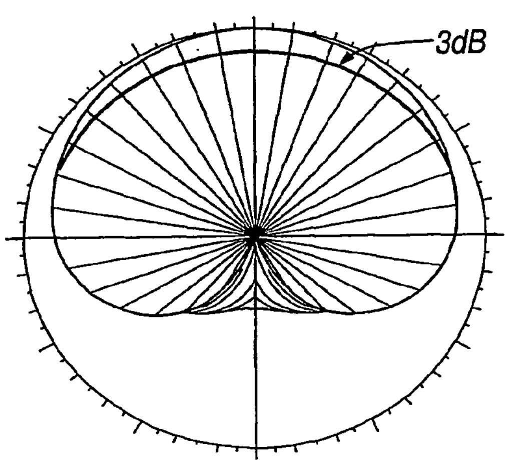


Fig12A

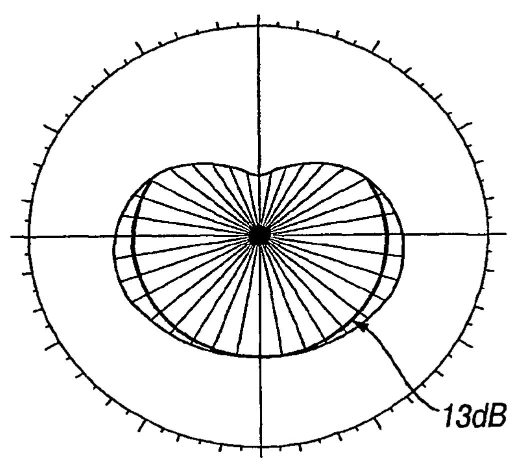


Fig12B

INTERNATIONAL SEARCH REPORT

Inte ıal Application No
PCT/GB 01/01665

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01Q9/06 H01Q9/26 H01Q9/28 H01Q21/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, INSPEC, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 672 386 A (WOOD COLIN) 9 June 1987 (1987-06-09) column 2, line 13 - line 62; figure 1 ---	1-4, 11-14
X	FR 2 429 504 A (FRANCE ETAT) 18 January 1980 (1980-01-18) page 4, line 33 - line 36 page 5, line 7 - line 29; figure 1 -----	1-3,9, 10,12

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 June 2001	27/06/2001
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Authorized officer Moumen, A

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Inte al Application No
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Patent document cited in search report		Publication date	Patent family member(s)			Publication date
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